

CLAIMS

What is being claimed is:

1. A method of manufacturing a light-emitting diode comprising:
forming an n-type layer of GaN over a substrate;
forming an active region over the n-type layer;
forming a p-type layer over the active layer, the p-type layer having a varying composition and a varying concentration of a dopant;
forming an n-type contact and a p-type contact, the n-type contact being connected to the n-type layer, the p-type contact being connected to the p-type layer.
2. The method of Claim 1, further comprising doping the p-type layer with a Group II dopant selected from Be, Mg, Ca, Sr, Zn, Cd, and C.
3. The method of Claim 1, wherein the Group II dopant is magnesium, the method further comprising doping the p-type layer with a co-dopant selected from a group consisting of Si, Ge, O, S, Se, and Te.
4. The method of Claim 1, further comprising:
doping a region of the p-type layer adjacent to the active region to a first concentration; and
doping a region of the p-type layer adjacent to the p-type contact to a second concentration, wherein the first concentration is less than the second concentration.
5. The method of Claim 1 further comprising varying a composition of aluminum from 20% in a region of the p-type layer adjacent to the active region to 0% in a region of the p-type layer adjacent to the p-type contact.
6. The method of Claim 1 wherein the p-type layer is a superlattice, and wherein forming a p-type layer further comprises:
forming a first sublayer of doped p-type material; and
forming a second sublayer of doped p-type material, wherein a concentration of dopant in the second sublayer is less than a concentration of dopant in the first sublayer.
7. A light-emitting diode comprising:

a substrate;

an n-type layer of GaN, formed over the substrate;

an active region, formed over the n-type layer;

a p-type layer, formed over the active layer, the p-type layer having a varying composition and a varying concentration of a dopant;

an n-type contact and a p-type contact, the n-type contact being connected to the n-type layer, the p-type contact being connected to the p-type layer.

8. The light-emitting diode of Claim 7, wherein the p-type layer dopant is a Group II dopant selected from Be, Mg, Ca, Sr, Zn, Cd, and C.

9. The light-emitting diode of Claim 8, wherein the Group II dopant is magnesium and the p-type layer further comprises a co-dopant selected from Si, Ge, O, S, Se, and Te.

10. The light-emitting diode of Claim 7, wherein the p-type layer comprises a material selected from III-nitride, III-nitride arsenide, III-nitride phosphide, and III-nitride arsenide phosphide.

11. The light-emitting diode of Claim 7, wherein the p-type layer has a thickness between 5 and 200 nm.

12. The light-emitting diode of Claim 7, wherein a first concentration of the dopant in a region of the p-type layer adjacent to the active region is less than a second concentration of the dopant in a region of the p-type layer adjacent to the p-type contact.

13. The light-emitting diode of Claim 12, wherein the dopant is magnesium and the first concentration is about $1 \times 10^{18} \text{ cm}^{-3}$ to about $5 \times 10^{19} \text{ cm}^{-3}$.

14. The light-emitting diode of Claim 12, wherein the dopant is magnesium and the second concentration is about $5 \times 10^{19} \text{ cm}^{-3}$ to about $1 \times 10^{21} \text{ cm}^{-3}$.

15. The light-emitting diode of Claim 7 wherein the p-type layer comprises a varying composition of aluminum.

16. The light-emitting diode of Claim 15 wherein the composition of aluminum varies from about 20% in a region of the p-type layer adjacent to the active region to about 0% in a region of the p-type layer adjacent to the p-type contact.

17. The light emitting diode of Claim 7 wherein the p-type layer comprises a varying composition of indium.

18. The light emitting diode of Claim 17 wherein the composition of indium varies from about 0% in a region of the p-type layer adjacent to the active region to about 40% in a region of the p-type layer adjacent to the p-type contact.

19. The light emitting diode of Claim 7 wherein a driving voltage of the light emitting diode is less than about 3.5 volts.